Synthy-64™

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Turn your Commodore 64 into a music synthesizer.

A Product of
The Software Guild

SYSTEM REQUIREMENTS

Standard Commodore 64™ Computer
Datasette™ Tape Player • Color TV or Monitor
External Amplifier or Sound System (optional)

PACKAGE CONTENTS

Synthy-64 Cassette
Instruction Manual
Warranty Card

OVERVIEW

In the age of the computer, technology has rendered the spirit of man yet another gift. Synthy-64 is the easy-to-use program that takes full advantage of the amazing versatility of your computer so you can compose your own synthesized electronic music! With Synthy-64 your Commodore 64 Personal Computer is transformed into a musical instrument with which you can create harmonies, songs, or even symphonies! The latest sounds from planet Earth are now yours with Synthy-64.

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I. Introducing Synthy-64

When Commodore Business Machines, Inc., decided to create an upgraded version of the VIC-20, they followed their previous design policy of loading the machine with features of every kind, allowing the personal computer enthusiasts to decide what strange and wonderful things to do with all this power. One of the great strengths of the 64 is the programmable sound chip, SID 6581, which makes available for a few hundred dollars what used to cost serious and commercial composers a great deal of money and time.

Wherever you go in the modern world, you are surrounded by the sound of electronically synthesized music. Not only intentionally strange "spacey" sounds fill the air waves; much of what you hear in movie and television sound tracks and pop records, although it sounds as if it had been produced by conventional orchestral instruments, is actually produced entirely by electronic means.

One of the main attractions of personal computers is the tremendous power you get for a relatively small investment in time and money. The Synthy-64 program fits right in with this trend. If you are an accomplished musician, this new tool will encourage you to push yourself farther. If you are a beginner, or would like to experiment with electronic music but don't want to face the years of study that such things traditionally take, you can sit down with this program and sample the technology immediately.

The organization of this manual takes you from the simple to the complex, and from theory to practical usage. In Chapter II you'll be introduced to the fundamental operations of Synthy-64. You will find introductory exercises that give you a feel for the programming of tunes, without reference to the tonal manipulations that make electronic music unique. Chapter III contains detailed instructions for the notation, editing, and saving of compositions. Chapter IV introduces the theory behind sound synthesis—but don't let the term "theory" alarm you. If you wish, you can learn to use Synthy-64 to full effect, including advanced features such as rhythm, repeats, and three-part harmony, without ever knowing the reasons why things sound the way they do. Chapter V outlines the error messages that may occur while you are using the program, and provides suggestions on how to get going again.

GETTING STARTED

To get started with Synthy-64, simply follow these steps. (This is called "booting.")

1. Place your tape recorder as far away from your monitor as you can.
2. Turn on your Commodore 64 computer (the power switch is on the lower right side of the computer) and your monitor or TV.
3. Insert the Synthy-64 cassette in the tape recorder and rewind it.
4. Type LOAD and press (RETURN).
5. Press (PLAY) on the tape recorder. The screen will go blank for a moment and then it will say SEARCHING, followed by FOUND SYNTHY-64. The screen will blank out again, and the program will load. This takes a few minutes. When the program has loaded, you will see READY displayed on your screen.
6. Type RUN and press (RETURN).
7. When you see the Synthy-64 title and first menu, type 1 and press (RETURN). This will load the sample compositions file, MUSIC-64, from the cassette. After this program has loaded, press (STOP) on the tape recorder.

THE SAMPLE COMPOSITIONS

The file on your cassette named MUSIC-64 consists of three familiar compositions which have been programmed as a demonstration of the various capabilities of Synthy-64. When you see the menu screen, type 1 and press (RETURN) and enjoy the first piece of music. Take this opportunity to adjust your TV set volume control to a comfortable level.

The first selection, "Battle Hymn of the Republic," includes various special effects as well as more conventional musical sounds. These are a very small example of the range of weird and wonderful sounds that you will be able to generate. To give you an introduction to the parameters that control the sound synthesis, "Battle Hymn" displays the "Trace Screen" as it plays. The Trace Screen is a valuable tool that helps you relate the various programming commands to the way the music sounds as it is being played. Notice that the number of the line that is currently being played is displayed at the bottom of the Trace Screen. Another useful feature of the Trace Screen is that when the program comes to a halt, either because you press the (RUN/STOP) key, or because the computer has run into a command it can't understand, the line number and relative character position is identified on your screen.

For the first run-through, just look at the screen. We will explain all these mysterious looking elements later in this manual.

After you have listened to "Battle Hymn," you return to the menu, where you can choose the other two selections. As you listen to "Beer Barrel Polka" and "Moonlight Sonata," note how the tone, timbre, and volume of the voices are varied. All of these variations are under the control of Synthy-64, and are predetermined in the form of a BASIC program.

HOW TO GET THE MOST OUT OF SYNTHY-64

Roy C. Wainwright, the author of Synthy-64, called upon his skills in two areas in order to produce this program: musicianship and programming. You should be reasonably conversant with BASIC programming, and with the general functions of your Commodore 64, as you begin using Synthy-64. Likewise, the more you know about music and musical notation, the easier your composing tasks will be. However, Synthy-64 is also easy to use on a beginning level, and, once you get started, you'll rapidly gain fluency. Use the same approach professionals do to reach Carnegie Hall—practice, man, practice!

If you would like to learn more about the features of your Commodore 64 computer that make music and sound synthesis possible, the reference book *Commodore 64 Programmer's Reference Guide* can help you. Pages 183 through 208 contain a detailed explanation of the sound chip and controls.

As you'll see later, you can save your compositions on a regular data tape in your Datasette tape recorder, just as with any other program. This means you can work on a song for a while, save it, and resume work another day when you feel motivated and creative.

IMPROVING ON TV SOUND

If you are using your home color TV receiver as your computer monitor, you have not been hearing the full range of sound that your computer is capable of putting out. (For that matter, you have not been hearing the full range of sound that broadcast television has. It's an axiom in the TV business that, until recently, with every four hundred dollar television set, you get a 79 cent speaker). The little speaker in your TV is sufficient for the razzes and booms of arcade games, but for music, we would like something better. If you have the equipment, you can play your computer output through a hi-fi stereo music system. You'll hear a world of difference.

To do this, you need the following:

- an earphone jack on your TV,
- an auxiliary input jack on your stereo (sometimes labeled AUX or TAPE), and
- a patch cord to reach from your TV to your stereo.

Connect the systems together, turn the volume controls down low on both the TV and the stereo, and turn both these and the computer on. Load the Synthy-64 program and the demo file. Start one of the demo selections playing, and slowly turn up the volume controls, first on the TV and then on the stereo. When you have reached a reasonable balance and loudness, you may like to manipulate the tone controls on the stereo, to adjust the sound to your liking.

(Please note that when we say "stereo," we are using the common term for music reproduction system; the output of Synthy-64 is monaural, that is, one channel of sound, not two.)

One last tip: If you have a cassette or reel to reel tape deck connected to your music system, you have the capability to record your Synthy-64 compositions directly as they are played from the computer.

II. Your First Compositions

The easiest way to learn to use Synthy-64 is to try a few compositions. To write music using this program, you enter the notes and other commands into your computer using the line editor, just as if you were typing in a program.

Actually, the "sheet music" of a Synthy-64 composition is a BASIC program, and it follows most of the rules of BASIC. Each line starts with a line number. You use the normal line editing features of your computer to type in or change any program line. To correct a line, move the cursor to the screen location containing the mistake and key the new material over the old. To delete a line, just type the line number and press the [RETURN] key. The LIST command functions just as it does in BASIC programming.

Let's begin. With the demo file in your computer, first clear the music memory space. To do so, press the [RUN/STOP] and [RESTORE] keys together. The screen changes at this point to the familiar blue display of the command (non-program) mode. Hold down the [SHIFT] key and [C], and then press [RETURN]. Synthy-64 will clear out part, but not all, of the resident BASIC code. Type LIST [RETURN], and you'll see:

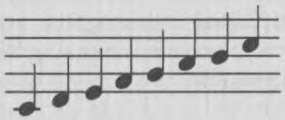
```
    1 RUN "<clr>"
63000 REM
63005 REM *******
63010 @WP @P8 @A0 @D9 @S0 @R0 @F0 RETURN          PIANO
63020 @WT @A4 @D2 @S10 @R5 @F0 RETURN             FLUTE
63030 @WS @A6 @D0 @S10 @R1 ZB X10 Y12 @F1 RETURN  TRUMPET
63040 @WP @P1 @A0 @D9 @S0 @R0 @F0 RETURN          BANJO
63050 @WS @A6 @D5 @S2 @R2 ZH X8 Y12 @F1 RETURN    ACCORDION
```

The 1 RUN "<clr>" must be the first statement in every Synthy-64 composition. The lines numbered 63010 through 63050 are five separate tone-setting routines. The various cryptic 3-digit values in these lines are the parameters that tell Synthy-64 what characteristics the music will have. You will see how they are used a little later.

Now that the code from "Battle Hymn" and the other demo selections has been cleared out, you are ready to key in your own compositions, using line numbers 2 through 62999.

PLAYING A MAJOR SCALE

Let's program a scale, starting at middle C. Type in the following, pressing (RETURN) after each line.

```
10  T120
20  C5/4 D5/4 E5/4 F5/4 G5/4 A6/4 B6/4 C6/4
30  END
```

After entering in this segment, LIST it and check for errors. If it all appears to be correct, type RUN (RETURN) to hear your first Synthy-64 tune.

Here's a brief explanation of the code involved in producing the scale. Line 10 sets the tempo. The tempo command controls the rate at which the music is played. The number in the T command tells the program how many quarter notes are to be played each minute. A higher number will make the composition play at a faster rate. If you don't enter any tempo command, Synthy-64 assumes a tempo of 100.

Line 20 contains the code for the actual notes to be played. The commands may look a little complicated at first, but you can easily understand the notation once you gain a little experience with the program. Look at the first command, C5/4. C is the pitch of the note, and 5 is the octave. (See Appendix A for the ranges of the octaves.) The /4 indicates that this note is to be played as a quarter note. The rest of the notes in line 20 are treated in a similar way.

Line 30 contains the familiar BASIC keyword END. The function of this command is the same as in regular programming; to signal the end of processing.

Now to streamline our scale program a bit. Press (SHIFT-C) (RETURN). As you'll recall, this clears out the main programming area. Now type

```
10  T120
20  C5/4 D E F G A6 B C
30  END
```

pressing (RETURN) after each line. RUN the program. Sounds just like the previous example, doesn't it?

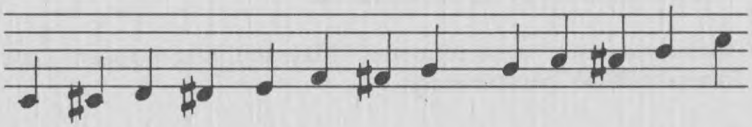
What we have achieved is cutting down on the keystroking and program length by taking advantage of the "inheritance" feature of Synthy-64. Simply stated, any time you establish a value for one note, be

it duration, octave, or other modifier, the value holds in force for any succeeding notes until it is changed. (This is similar to the way in which you use POKEs in BASIC programming. Once something is POKEd into a a memory position, it stays in force until something else is POKEd over it.)

Therefore, once you have established that the first note, C, is to be played as a quarter-note in the 5th octave, each succeeding note is also played with these two characteristics (octave and duration), until otherwise specified. Notice that, when the program reaches the note A, it's necessary to tell Synthy-64 to move up to the next octave, octave 6. This is because each octave begins with A. If we didn't put the 6 after the A, it would inherit octave 5, and would be an octave too low. The B and C notes immediately following, however, automatically inherit the new octave specification of 6.

ADDING SHARPS AND FLATS

Now let's change the scale by introducing sharps. Clear out the old program, using the technique demonstrated previously. Then type

```
 1 RUN"<clr>"
10 T100
20 C5/4 C# D D# E F F# G G# A6 A# B C
30 END
```

Run this one, and you will hear a a full 13 note chromatic scale. In Synthy-64 language, sharps are indicated by the # sign and flats by the % sign. You may indicate a natural by using the $ sign. (The latter two are unlike sheet music notation, but a computer keyboard does not have the conventional flat and natural symbol keys.)

ADDING RHYTHM AND RESTS

Now you know how to program any note or pitch. You can also vary the note duration. To do so, type a / followed by the appropriate value. A whole note is written as /1, a half-note as /2, an eighth-note as /8, and so on to 64th notes. Since you have the power to set the tempo using the T command, you can program your compositions to play in many different rhythms and speeds.

Try changing line 20 in the previous example from quarter notes to eighths or sixteenths, and run the program again. Next, try adding different durations to some of the notes in the scale.

Rests are programmed similarly. The format is R/n, where n is the modifier. Put a quarter rest (R/4) between two notes of the scale and check the results.

REPEATING MUSICAL PHRASES

Many pieces of music contain phrases which are repeated. Synthy-64 provides a powerful command, allowing you to repeat stanzas. Clear the music memory space again and then enter

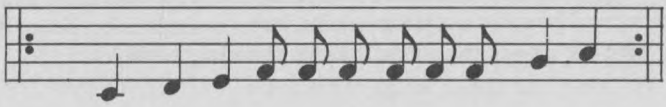
```
 1 RUN "<clr>"
10 T80
20 [5 C5/4 D E F G A6 B C ]
30 END
```

This time the scale plays five times before ending. The [(left square bracket) signifies the beginning of the phrase to repeat. The] (right square bracket) marks the end. The number 5—called the Repeat Factor—immediately following the [is the number of times that the segment is to be repeated. When Synthy-64 sees the [, it plays all of the music up to the], then jumps back to the beginning of the repeat and runs through the segment again. This happens for the number of passes specified by the Repeat Factor.

You may also nest repeat segments. This is similar to the use of loops in regular BASIC programming.

Example:

```
20 [3 C5/4 D E [2 F/8 F F ] G/4 A6 ]
```



Notice that the program requires a space before the closing], but not after the opening [. This space or lack of space is used by Synthy-64 in deciding where one command ends and the next begins. You'll see this explained in more detail later in this manual.

At this point, you have all the necessary information to compose a simple tune with the melody, rhythm, and tempo of your choice. After you've experimented with the commands and have composed some of your own music, you may want to save your composition for

replay at some later time. Insert a blank, rewound cassette in your tape recorder, and then follow the same procedure that you use in saving non-musical program material. Type in SAVE"MYSONG" (or whatever name you choose) and press (RECORD) and (PLAY) on the tape recorder.

III. Synthy-64 Commands

In this section we are going to get into the real meat of the program, the powerful commands provided by Synthy-64 that help you realize your musical ambitions. As you read through this material, you will notice that some information appears to be presented in more than one location. We adopted this structure to help you use the manual in the way you prefer, without having to search back and forth for some particular command or procedure.

Of course, there is a vast wealth of information about music, sound, computers in general, and the Commodore 64 in particular, which we can't include in this manual. You can gain much valuable background knowledge from the *Commodore 64 Programmer's Reference Guide*, distributed by Howard W. Sams & Co., Inc., which should be available at your computer dealer. Also, contemporary music magazines such as *Keyboard* and *Mix* often feature articles about the latest developments and uses of electronic music synthesis.

NOTATION COMMANDS

Pitch

The pitch of a note in Synthy-64 is coded according to the standard conventions of Western music. The notes are A to G sharp, with the octave break at each A. Refer to Appendix A for the pitch range.

Example: The notes in a major scale from Middle C to the C an octave higher appear in a program line as

```
C5 D5 E5 F5 G5 A6 B6 C6
```

Octave

The octave range is from 1 through 8, with C1 being the lowest available pitch, 4 octaves below middle C, and G8 sharp being the highest, 3 octaves and a fifth above middle C (C5). The octave modifier number immediately follows the note. Due to a feature called "inheritance," when you specify an octave for a note, it holds in force for the succeeding notes in the program until you specify a different value. In other words, C5 D5 and C5 D both produce the same two notes.

Accidentals

Sharps, flats, and naturals are used in the conventional way, but with some different symbols. The symbols to use with Synthy-64 are shown as follows:

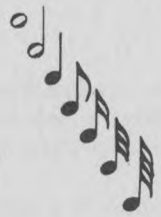
Standard	Synthy-64	Meaning
#	#	sharp
♭	%	flat
♮	$	natural

The accidental modifier should be placed right after the pitch value, before any other modifier.

Examples: C#5 = C sharp just above middle C
B% = B flat
E$7 = E natural in the seventh octave

Duration

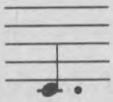
The length of time that each note is played is controlled by the **note duration factor**. A note duration is specified after the note pitch value by using a /, followed by a duration value. The allowable time values are shown as follows

Synthy-64	Meaning	Standard Notation
/1	Whole note	
/2	Half note	
/4	Quarter note	
/8	Eighth note	
/16	Sixteenth note	
/32	Thirty-second note	
/64	Sixty-fourth note	

Examples: A4/4 = A natural in 4th octave, quarter note
E%6/2 = E flat in 6th octave, half note

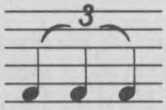
Duration modifiers are used to signify dotted or triplet notes. The modifier is added immediately after the duration value.

.	(period)	A dotted note—one and one half value
:	(colon)	Double dotted note—one and three fourth value
!	(exclamation point)	Triplet—two thirds of a quarter note

Examples: C5/4. Plays middle C for one and one-half times as long as a quarter note



F4! F4! F4! Plays three F's as a set of triplets

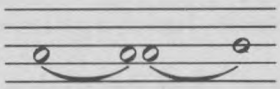


Rests are specified by using the symbol R followed by a duration value. You can use the same duration and duration modifier values for rests that you do for notes.

Examples: R/4 Rest for a quarter note (1 beat)
R/2. Rest for one and one-half times as long as a half note (3 beats).

Tied notes are specified with the ← symbol. The tie symbol must follow the first note of the two to be tied.

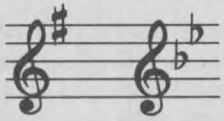
Examples: A←A Plays note twice as long without a break
A←B Smooth transition from A to B



Key Signature

You may set the key signature just as in conventional sheet music. Use the command SGN followed by the appropriate number of sharps or flats. If a key signature is not specified, C major (no sharps or flats) is assumed.

Examples: SGN#1 Key of G major
SGN%2 Key of B flat major



Tempo

The Tempo command controls the rate at which Synthy-64 plays your music. The format of the command is the letter T followed by a number between 15 and 255. The higher the value, the faster the tempo. If you do not set a tempo at the beginning of the piece, a tempo of 100 is assumed. You can figure out approximately how fast

a tempo to specify by listening to the sample compositions. "Battle Hymn" is played at T100, "Beer Barrel Polka" is played at T200, and "Moonlight Sonata" at T80.

Example: T100 Default value, a medium tempo

You may use the T command to change the tempo at any point in a Synthy-64 program, even in the middle of a line.

Volume

The Volume command controls the level of **loudness** at which the music is played. The format of the command is the letter V followed by a value between 1 and 15, with 1 being the softest and 15 the loudest. If you do not specify an initial volume command, a volume level of 15 is assumed.

You may change the volume level at any point in the program. In fact, you may change the setting between two notes in a phrase by inserting the V command between two note commands.

VOICE PREFIX COMMANDS

There are three different tone generators in the Commodore 64; hence Synthy-64 can play in up to three voices simultaneously. This polyphonic ability is one of your computer's most impressive features; many commercial synthesizers are limited to one voice. Please refer to your *Commodore 64 Programmer's Reference Guide* for a detailed technical explanation of the tone generators and their functions.

The symbols for these voices are shown below. If you don't specify a voice to use, voice one is assumed.

+	Voice One
–	Voice Two
£	Voice Three

Please note that these voices are just plain tone generators. They have no individual characteristics in terms of waveform or musical quality until you assign such characteristics with other Synthy-64 commands.

CONTROL COMMANDS

These control commands are for use in your musical composition program. They are, for the most part, similar to BASIC programming commands used in regular programs. Consult your Commodore 64

manual or one of the many books on BASIC programming for further information.

END

The keyword END is used to signify the end of the composition (program). Upon reaching an END command, Synthy-64 returns to the line editor.

GOSUB

This command allows transfer of program control to a subroutine section. The subroutine is performed until the computer encounters a RETURN command, which returns control to the main program line.

GOTO

This command transfers program execution to the line specified.

INPUT

This causes the program to stop execution until you type a number and press (RETURN). Once you do, the operation is similar to the BASIC programming structure ON—GOTO (see page 64 in the *Programmer's Reference Guide*). You must prespecify the allowable branch line numbers, and command will be transferred according to the number input.

Example:
```
400 INPUT2000,8000,10000,15000
410 GOTO400
```

When the program is run, if 1 is input, the program will GOTO line 2000; if 2 is input to line 8000; and so on.

Please note that there is no space between INPUT and the first line number specification, or between GOTO and 400. It's important to adhere to this structure; if you leave a space, Synthy-64 thinks that a new command is beginning, and the program crashes.

REPEAT

Repeats in Synthy-64 are signified by the [(left square bracket) and] (right square bracket). This sequence of commands tells the program to repeat the segment of music between the opening and closing brackets. You must insert a number immediately after the opening bracket, which tells the interpreter how many times to execute the repeat. This number is called the "Repeat Factor." After the specified number of repeats have been played, the program proceeds to the next executable command.

Example: [3 C5 D E] Repeats the passage three times before going on

Repeats may be nested within repeats, just as in nested loops in conventional BASIC programming. You may nest repeats up to 27 levels (which could allow you to compose a piece that would play for days!), in which all the repeats in the innermost loop would be done, and then on to the next outward layer, and so on.

Example: [2 [2 C D E] [2 E C D]]
Plays (C D E) twice, then plays (E C D) twice, then loops back and does the whole thing again

Note that there is no space between the [and the Repeat Factor number. However, you must precede each] with one space.

RETURN

The use of this command is exactly the same as it is in BASIC programming. RETURN is placed at the end of a subroutine, and directs execution back to the next line or command after the calling GOSUB.

Example:
```
100 GOSUB 150
150 REM do something
160 RETURN
```

STOP

When you insert STOP in a program line, Synthy-64 ceases playing, and displays the line number and character position of the stopping point on your screen. The program also displays the Trace Screen, with the various option values as they were at the stopping point. This can be very useful in debugging difficult parts of a composition.

OTHER RUNTIME COMMANDS

" " (DISPLAY)

Use the open and close double quotes to display any text or characters on the screen. All cursor and screen controls that you normally use in BASIC are usable within the quotation marks. You can use this function to print the title of the song or, during the composition phase of your music, to indicate when certain sections begin and end.

Example:
```
100 "Moonlight Sonata"
200 "begin part two"
```

REM

You may place remarks anywhere within the music program. REMs are not played, but serve only as comments to the composer. All statements to the right of the REM are treated as comments, so don't place any other Synthy-64 commands on the same line following a REM.

Example:
```
100 REM begin second repeat section
110 ] REM end of repeat
```

WAIT

This command causes Synthy-64 to wait, or pause, for a number of seconds before continuing to the next command or line. This is useful for pausing for a length of time that is not possible to designate with rests. The WAIT command is immediately followed by the Factor Number, containing up to three digits.

Example:
```
10 T120
20 "<CLR> MY FIRST COMPOSITION"
30 WAIT10 REM let everyone read the title
```

OPEN and CLOSE TRACE

A Trace Function is included in the Synthy-64 program so that you can keep track of all the generator controls and voices. When you use it, every command and function is displayed on the screen as the program progresses. (The Trace Screen is the same as the one that appears whenever your program halts because of a stop command or an error.) The command is started by inserting a < (less-than) symbol into a program line. It is turned off by inserting a > (greater-than) symbol.

Example:
```
1161 "TRACE FUNCTION" <
1162 > REM END TRACE
```

Because your computer must do a great deal of work in both playing the music and displaying the trace functions, the pace of the music is slowed down considerably. If the music is still being played too fast for you to follow the Trace Screen Functions, you can temporarily slow it down even more by changing the tempo specification to a lower value.

IMMEDIATE MODE COMMANDS

The following commands are used at the **command** level. Command level is computerese which simply means that the commands are directly entered when the program is not running, rather than commands which are within the program itself. In command level, you tell the computer what to do. In execution mode, the resident program tells the computer what to do.

LOAD

This command operates according to the general rules of BASIC. You may either specify a filename within quotation marks, as in LOAD "filename", or merely type LOAD and press (RETURN). The computer will load the next file on the tape.

LIST

This command is used exactly as it is in BASIC. You can list the entire program, or one line, or a range of lines. Consult your Commodore 64 manual for details.

You may also obtain a hardcopy listing if you have a printer. In the command mode, type each of the following commands and press (RETURN).

```
OPEN 1,4
CMD 1
LIST
PRINT #1
CLOSE 1
```

RUN

This command starts the resident program. Synthy-64 will begin playing your composition at the first executable line. Please remember that the first line of your program must also contain the keyword RUN.

SAVE

This command is used in the same way as it is in BASIC. You may SAVE a file without specifying a filename, but it is better to label each file in the usual manner, especially if you have more than one file on a cassette.

SHIFT-C

This command is specific to Synthy-64. It is used to clear the entire music composition part of your program, with the exception of line 1 and the 63000 subroutines (listed earlier) that prespecify various

voices. Press [RUN/STOP] and [RESTORE]. Then type [SHIFT-C] and press [RETURN]. When you list the program, you will find that Synthy-64 has cleared out all instructions and specifications, and preserved only the first line:

```
1 RUN"<clr>"
```

The <clr> appears as a reverse heart-shaped symbol in this line. Its function is to blank the screen before beginning to play the composition.

SHIFT-K

This command is also specific to Synthy-64. When you type [SHIFT-K] and press [RETURN], the music interpreter program is removed from your computer. This resets your Commodore 64 to BASIC.

IV. Electronic Sound Synthesis—Theory and Practice

We live in a vast range of vibration, from the slow groan of the turning earth to the impersonal crackles of the distant stars. As humans, we detect a very small range of these vibrations and call them sound. Then, by general agreement, we choose a tiny selection of sounds and call these music.

Imagine a sound produced by some mechanical means—a pure, continous sound. You have to imagine such a thing—it does not exist in nature. But your microcomputer is capable of coming very close to such a sound. Just as sunlight is said to contain all colors, pure sound may be said to contain all tone, timbre, and other characteristics. By various shaping processes, we arrive at a set of characteristics that make a sound unique. The SID chip in your Commodore 64 allows you to experiment with these characteristics.

Practically speaking, it is the tonal characteristics that make a trumpet sound like a trumpet, a bomb blast like a bomb blast, or a crying baby like something you'd better attend to. As you'll see, we "synthesize" sound by applying to it the tonal characteristics that we desire.

This trick is done with the SID 6581 microchip and some associated electronics, such as filters. This powerful combination can be controlled by programming, either through machine code (the very hard way), by POKEs in a BASIC program (less hard, but very time-consuming), or by simple commands in the Synthy-64 program.

This section of the manual is divided into two parts. In the part immediately following, we'll consider the theory behind the various **control options** available in Synthy-64. In the next part, you'll see a detailed explanation of the **actual commands** and how to use them. If you have already composed and saved compositions using the notation commands in the earlier part of this manual (covered in the last part of "Your First Compositions"), you can now reload a song and experiment with control options. Just use the Commodore 64 line editor to add the various commands in the appropriate lines.

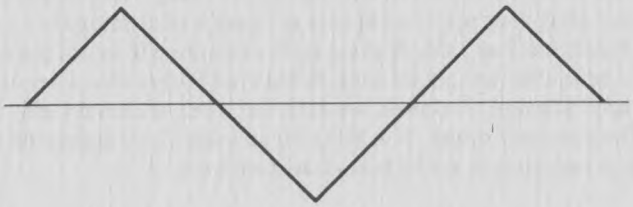
ELEMENTS OF TONE GENERATION

Waveform

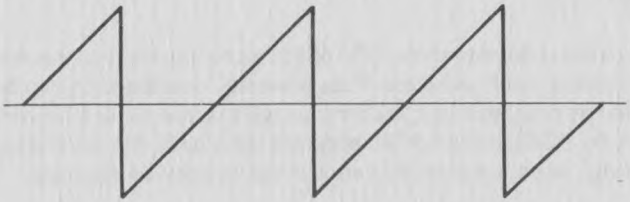
This is the starting point. There are four possible waveforms from which to choose. Your program must specify one of these waveforms, or no tone will be generated. It's the waveform of the basic sound which helps to determine its broad characteristics. If you have access to an oscilloscope, you can examine the appearance of some of these waveforms, and gain an idea of the relationship between shape and sound.

The waveforms available in your computer are listed as follows.

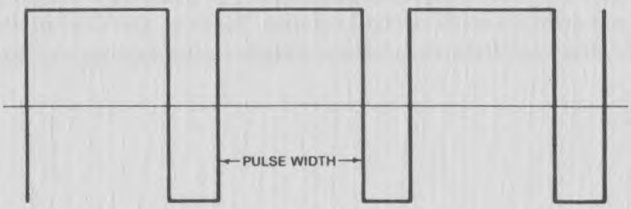
Triangle—this is a muted and "fluty" sound.



Sawtooth—this is a bright, peaky, and "brassy" sound.



Pulse—this is a "binary" type of wave, in that it is either totally on or totally off. Depending on the "duty cycle" (proportion of on time versus off time), the result can vary, but is generally rather hollow sounding.



Noise—this is a "rushing" sound, composed of random frequencies, like the sound you hear when you tune your TV or FM radio to an unused channel.

Pitch

Pitch refers to the **frequency** (number of vibrations or cycles per second) of the basic tone. A pitch of zero is silence. A pitch of approximately 460 corresponds to the note A on the piano. You sharp-eyed musicians may now wonder why the computer uses 460 cycles for concert A, when the international standard for acoustic instruments is 440. The reason has to do with adjustments in the logarithmic division rate, to make the scale more pleasing to the human ear than a purely mathematically accurate scale seems to be.

Your computer is capable of generating a wide range in pitch, in fact well beyond the range of human hearing.

Envelope Generator

One of the most important aspects of synthetic sound generation is the envelope generator. This refers to a collection of characteristics that give a sound its "signature." The four major parameters of the envelope are **attack**, **decay**, **sustain**, and **release**. You will often see this referred to as ADSR in synthesizer literature. There is a more elaborate explanation of these terms in the Programming Sound and Music Chapter of the *Commodore 64 Programmer's Guide*, starting on page 196. A brief explanation of each parameter follows.

Attack: Very few sounds are perceived as just beginning cleanly, at full volume. There is almost always some delay in the buildup from silence to maximum strength, although the delay may be too slight to be noticeable. This is what attack means. A quick attack causes the sound to seem to begin instantly. A slow attack causes a longer buildup to full volume. In Synthy-64, the range of attack values is from 0 to 15, with 0 being the quickest and 15 the slowest.

Decay: This controls how fast the sound goes to the sustain level. Some sounds decay almost immediately, for example, percussive noises. When a drum is struck, there is no sustain period to the sound;

at the impact the sound is at its loudest, then immediately begins to die away. On the other hand, many wind instruments like trumpets have a characteristic sound formed by a loud attack, then a slight drop in volume to the level of the main or sustained tone. Many of the strange sounds that we associate with electronic music feature unusual patterns of attack and decay that just don't exist in nature. For instance, imagine a "backwards cymbal," that begins with a very tiny sound and then swooshes up to a loud sound before cutting off abruptly.

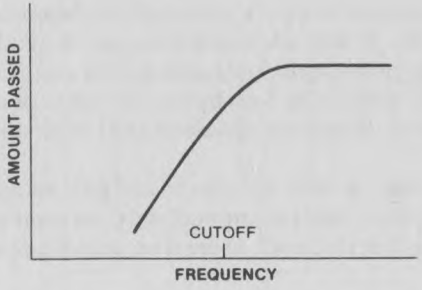
Sustain: This is the level at which the sound is played until it is shut off. Again, the range is 0 to 15. If the sustain level is 15, the sound will play at full volume until stopped. If it is 0, there will be no sustain. The numbers inbetween represent steps in volume level. Most conventional stringed instruments have a long and full sustain period, ending with a medium release.

Release: This value can be thought of as the opposite of attack. It determines how quickly the sound is shut off. If a value of 0 is specified, the tone will shut off immediately. If the value is 15, the tone will die away gradually. The higher the value for release, the longer it will take for the tone to dwindle to silence.

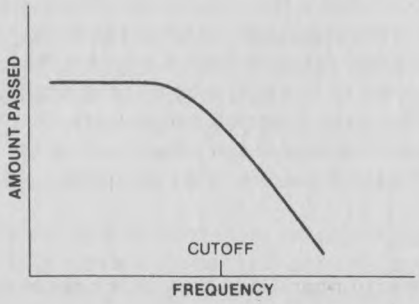
PROGRAMMABLE FILTER

The sound chip also includes a programmable filter. Each of the three generator tones may be routed through this filter. There is a software "switch" to control this option for each voice. The filter has the following functions:

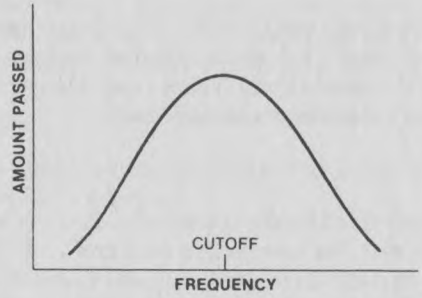
High-pass—emphasizes the high tones while diminishing the lows



Low-pass—emphasizes the low tones while diminishing the highs



Band-pass—filters out the high and low tones and emphasizes a range of middle tones.



The filter can operate in any of these modes, or all three at once. The frequency setting of the filter is controllable from low to high by setting a value in the proper control commands.

SYNC AND RING MODULATION

Voice three has a unique switch which allows you to turn its sound output off while still retaining various features, such as pitch and duration. You might reasonably ask, "Who cares what pitch the voice has if it is inaudible?" In this mode, voice 3 is used to affect the sound of the other voices through Sync and Ring Modulation control. The Sync control switch causes one generator to "lock on" to the frequency of another generator. This feature can be used to create a complex sound wave by using two generators together.

Specifically, generator 1 syncs from generator 3, generator 2 from generator 1, and generator 3 from generator 2. The resultant sounds elude written description—try a few, and you'll hear the eerie effects.

TONE GENERATOR CONTROL COMMANDS

Now that we have looked at the possibilities for tonal manipulation, let's tackle the various programming commands that will allow you to put the theories into practice. Please note that these option commands are to be inserted in the Synthy-64 program line in the same way as the ones for pitch, duration and so forth, that we discussed earlier. Each control command can refer to any of the three voices. The generator affected depends on the voice prefix (+, −, or £).

Set Attack Speed

The format for this command is @An, where n is a number between 0 and 15. An attack speed of 0 turns the sound on instantly. As the attack speed is increased to 15, there is a correspondingly longer buildup of sound.

Set Decay Speed

The format for this command is @Dn. The Decay speed factor is a number between 0 and 15. A decay speed of 0 causes no delay in a sound's going to its sustain level. A decay speed longer than 0 causes a delay in a sound's reaching its sustain level.

Set Filter

This option is controlled by the command @Fn. The legal modifier numbers are 0, 1, or 2. For tone generators 1 and 2, the choices are 0, which indicates that the filter is to be off, and 1, which sets it on. For generator 3, a value of 0 indicates that the filter is off, a value of 1 turns it on, and a value of 2 indicates that the output of generator 3 is to be turned off (as in the sections on "Sync" and "Ring Modulator", above).

Set Ring Modulator

This is another one of the on or off options, with 0 turning (or leaving) the Ring Modulator off, and 1 turning it on. The format is @Mn. When you use the Ring Modulator, you must set the output waveform to triangle.

Set Pulse Waveform

The format of this command is @Pn, where the range of n is 0 to 15. This command controls the Pulse waveform duty cycle. A value of 0 equals a 0% duty cycle, and 15 equals a 94% duty cycle. You should experiment with different values for this specification, and take note of the resultant variations.

Set Filter Frequency

This command allows you to set a specific frequency for the filter to operate on a generator or generators. One of the possible uses for this would be to make a certain note stand out, by sharply filtering the required pitch. The format of this command is @Qn, where the n factor is a number between 1 and 65535. See Appendix B for the correspondence of pitch numbers to musical notes.

Set Release Speed

The format for this command is @Rn, where the factor is a number between 0 and 15. A release speed of 0 shuts the sound off immediately when the release portion of the tone is reached. A release speed of 15 causes the sound to die out very slowly.

Set Sustain Level

This command sets the sustain level of a voice during the period after decay and before release. The format is @Sn, and the factor range for n is 0 to 15. A sustain level of 15 causes the sound to play at full volume until stopped. A sustain of 0 omits the sustain portion entirely.

Set Waveform

The format for this command is @Wx. The factor specifier x in this case is a letter. The choices are:

S —Sawtooth
T —Triangle
P —Pulse
N—Noise

Set Sync

The command @Yn turns the synchronization on or off. The modifying factors are 0 for off and 1 for on.

Set Filter Bandwidth

Zn is the command to set the filter bandwidth. The value n here is a letter—L, B or H. The settings are:

L —Low-pass
B —Band-pass
H—High-pass

Remember that low-pass cuts the high frequencies, high-pass cuts the low frequencies, and band-pass attenuates (de-emphasizes) both high and low, bringing out the middle frequencies.

POLYPHONY

Synthy-64 is capable of playing all three voices at once. This **polyphonic** or multiple voice feature allows you to program chords, harmony, and various other complex musical forms. By means of a read-ahead feature, the interpreter checks the next command even as it is performing the current command. If it finds that the next command specifies a different voice from the current one, it goes ahead and plays the next one, more or less simultaneously. You can use this feature to play two and three part harmony.

The only possible difficulty in coding is that the notes must be presented in the sequence that you want them to be played. Therefore if you desire a three-note chord, you have to program each of the three notes, one after another, so that they sound at once. Then you must indicate the following note for whichever voice must be played next. For example, to sound an inverted C major chord, E G C, you code as follows:

```
+E5/4 -G5/4 £C6/4
```

Synthy-64 reads the three note specifications, finds that there is a change of voice prefix in each case, and plays the three notes at once. Please note that each command specifies the same duration, a quarter note. If you specify differing durations, each note in the chord will be held for its individual duration. This could provide overlapping chord change patterns.

PORTAMENTO

This is the sweeping or gliding of a tone up or down the scale, without noticeable steps. Synthy-64 can do this with two commands. The command formats are @ ↑ n for a sweep up, and @;n for a sweep down. The n value is a factor that determines the rate of sweep. The time value is the same as that of duration for a regular note. In other words, the command @;4/8 will sweep down from the previous note to the next, using a duration of 4 eighth notes, or 2 beats in 4/4 time. "Battle Hymn," in your demo program, includes some examples of the use of portamento.

PRESET TONAL ENVELOPES

To simplify the programming process, the demo program includes several GOSUB routine lines with setups for different sounds. To use one or more of these, program an early line in your composition that will specify the voice generator code (+, −, or £), and then GOSUB to the appropriate line where the characteristics are specified. Each routine sets a voice to a different sound. The subroutine lines are shown below, and fully listed in Chapter II of this manual.

Line	63010	piano
	63020	flute
	63030	trumpet (notice the use of filter)
	63040	banjo
	63050	accordion (a mix of slow attack, decay, and filter).

V. Synthy-64 Error Messages

As the Synthy-64 music interpreter reads your music, it performs many checks. When it finds a command or specification that it does not understand, program execution will stop and you will see an error message. The interpreter will tell you the line number and relative character position at which it crashed. This allows you to LIST and revise directly, using the line editor.

Here are the error messages and probable causes:

INVALID COMMAND

Synthy-64 has encountered a character which is not a valid note or command. This error also occurs on a LOAD command without the leading quotation marks, or on a GOTO or GOSUB which is followed by a space insead of a line number. Another possibility is a [(begin repeat) or an N (skip) which is not immediately followed by a value factor.

STOP COMMAND

This works the same as it does in BASIC. The program halts execution, and the computer prints the line number at which the stop occurred.

GOSUB/STACK ERROR

This error will occur when GOSUB and RETURN commands get mixed up with [(begin repeat) and] (end repeat) commands. The program will not allow you to jump over these. These commands may be nested, but a RETURN must be executed after a GOSUB, just as a [must be closed by a].

RETURN, NO GOSUB

This error means that you have somehow gotten into a subroutine without executing a GOSUB command. Usually, you can clear this up by inserting an END command after the main routines and before the first subroutine.

OUT OF TEXT
↑LINE NOT FOUND

Synthy-64 has reached the end of the music program without a STOP or END command. This error will also occur with a GOTO, GOSUB, or INPUT command that branches to a non-existent line number. In this instance, the missing line number is shown above the arrow in the message.

STOP KEY

This message is displayed whenever you press the RUN/STOP key during the course of program execution.

VI. Warranty Message

Please take a moment to fill out and mail the enclosed Warranty Card. By having your name on file, we will be able to provide the best possible customer service, including information on program updates and replacement of damaged cassettes.

A great deal of effort has gone into preparing this program to operate smoothly and without "bugs." Should you have problems with this program, please contact our Customer Service Department at the following toll free number:

1 (800) 341-4000

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Customer Service
2935 Whipple Road
Union City, CA 94587

Consult your local Softsmith dealer for a catalog of our products and a demonstration of any of our software products.

Appendix A
Commodore 64 Octave Ranges

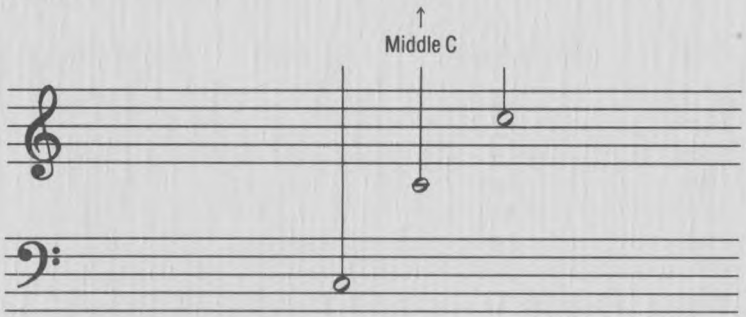
If you imagine that the following diagram corresponds to a piano keyboard, then you can see the relationship between the octaves in musical notation and the tonal ranges of the sound generators.

NOTE VALUE:

CDEFGABCDEFGABCDEFGABCDEFGABCDEFGABCDEFGABCDEFGABCDEFG

1 | 2 | 3 | 4 | 5 | 6 | 7 | 8

OCTAVE



Appendix B
Pitch Equivalency Table

Use this table to find the appropriate pitch setting for filters and other Synthy-64 options. Note that the pitch equivalency figures do not exactly jibe with the standard Hertz (cycles per second) of notes on the piano—i.e., concert A has a real value of 440, whereas our Commodore 64 pitch number is 460. This has to do with the way in which the computer forms the tones, by division based on the internal clock rate. There is also a "tempering" factor involved, in which some of the notes have been adjusted upward or downward to be more pleasing to the ear.

Note & Octave	Pitch	Note & Octave	Pitch
C1	274	B5	4143
C1#	291	C5	4389
D1	308	C5#	4650
D1#	326	D5	4927
E1	346	D5#	5220
F1	366	E5	5530
F1#	388	F5	5859
G1	411	F5#	6207
G1#	435	G5	6577
A2	461	G5#	6968
A2#	489	A6	7382
B2	518	A6#	7821
C2	549	B6	8286
C2#	581	C6	8779
D2	616	C6#	9301
D2#	652	D6	9854
E2	691	D6#	10440
F2	732	E6	11060
F2#	776	F6	11718
G2	822	F6#	12415
G2#	871	G6	13153
A3	923	G6#	13935
A3#	978	A7	14764
B3	1036	A7#	15642
C3	1097	B7	16572
C3#	1163	C7	17557
D3	1232	C7#	18601
D3#	1305	D7	19708
E3	1383	D7#	20897
F3	1465	E7	22121

Note & Octave	Pitch
F3#	1552
G3	1644
G3#	1742
A4	1845
A4#	1955
B4	2071
C4	2195
C4#	2325
D4	2463
D4#	2610
E4	2765
F4	2930
F4#	3104
G4	3288
G4#	3484
A5	3691
A5#	3910

Note & Octave	Pitch
F7	23436
F7#	24830
G7	26306
G7#	27871
A8	29528
A8#	31284
B8	33144
C8	35115
C8#	37203
D8	39415
D8#	41759
E8	44242
F8	46873
F8#	49660
G8	52613
G8#	55741